2013

The effect of an auditory stimulus on change blindness

Shane McCormack
University of Central Florida

THE EFFECT OF AN AUDITORY STIMULUS ON CHANGE BLINDNESS

by

SHANE MCCORMACK

A thesis submitted in partial fulfillment of the requirements
for the Honors in the Major Program in Psychology
in the College of Sciences
and in the Burnett Honors College
at the University of Central Florida
Orlando, Florida

Spring Term 2013

Thesis Chair: Dr. Mark Neider

ABSTRACT

This research examined whether or not an auditory stimulus would affect rates of change blindness. Change blindness occurs when there is a failure to detect an obvious change to a visual scene. For this experiment 40 participants were asked to determine if a change occurred between two pictures. This involved an original picture shown for 1 second, a neutral screen shown for 50 milliseconds and then either a modified version of the original image or the same image for 1 second and then repeated. Participants then determined whether a change occurred in the visual display. For some participants a familiar song played on repeat during the visual task. My goal was to determine if music would affect rates of change blindness and how quickly changes would be detected if present. I found that participants in both the music and non-music conditions were more accurate when there was no change to a scene. Participants in the music condition also took longer to respond as opposed to the control group. When examining reaction times of only correct responses, both conditions responded in a similar amount of time for pictures with changes. In trials with no changes the participants in the music condition took longer to respond than the control group. Overall, it appears that music had a negative effect on reaction times when a change was present. Participants were also more accurate in detecting pictures with no changes as opposed to pictures with changes.

TABLE OF CONTENTS

INTRODUCTION

A woman is driving through a neighborhood while trying to send a text message on her cell phone. While attending to her phone a child walks in front of the car to grab his soccer ball. The woman does not see the child walking into the street until the last second. A similar scenario occurred in a study by Haines (1991) involving experienced pilots flying in a flight simulator. When the experienced pilots proceeded to land on the runway they failed to notice an easily visible plane that was blocking the runway until it was too late and collision was unavoidable. In court, it is common for two witnesses who saw the same incident to notice things that another person failed to detect (Memmert, 2006). There are less critical incidences that occur on a daily basis such as when we walk right by a person we know and fail to see them even though we may have been looking directly at them. These situations are examples of how visual perception has limitations.

Inattentional Blindness

Observers with perfectly normal visual ability are often unable to notice the appearance of unexpected objects or significant unprecedented alterations to the environment. This applies not only to a controlled setting such as a laboratory but also to everyday situations (Kovisto, Hyona, & Revonuso, 2004). When people are focused on an object or event, they often fail to notice objects that would normally stand out. This phenomenon is known as Inattentional Blindness (IB). Beanland (2011) defined IB as the failure to notice an obvious but unexpected stimulus due to attention being applied to another activity. Memmert (2006) suggested that this phenomenon occurs because our conscious perception demands that we apply attention to stimuli in order to perceive it. If an observer's attention was applied to one stimulus, they could miss an unexpected object even when they are looking directly at it. Moore and her colleagues offered an operational definition for inattention by explaining that it occurs when participants fail to see the unexpected stimulus. After they fail to detect the item, if participants are forced to guess what the unexpected item was, the likelihood that they select the correct item from a list will be at chance levels (Lo & Yeh, 2008; Moore, Grosjean, & Lleras, 2003). Inattention is not the same operational phenomenon as unawareness. IB is an implied status because the observer must deny seeing an unexpected object in order for it to be classified as IB. Lo and Yeh (2008) reported that this subjective response of not noticing a stimuli can be confirmed by objectively measuring participants scores when forcing them to choose the unexpected object from a list of choices that could represent the unexpected stimulus in trial experiments. What is fascinating about IB is that most people intuitively expect that they will be able to notice an unexpected object or event. However, results indicate that in most cases the belief that someone would notice an unexpected stimulus is significantly overestimated (Kovisto, Hyona,& Revonsuo, 2004).

Classic Inattentional Blindness Studies

In most IB paradigms, a typical experiment involves a participant attending to a visual display, during which an unexpected visual stimulus appears (Beanland, Allen, & Pammer, 2011). In the classic experiment by Neisser (1979), participants were required to watch two basketball teams pass basketballs back and forth and count the number of passes they made. During this experiment a woman would walk across the basketball court holding an umbrella as the teams were passing the ball. In this experiment only 21% of the observers reported seeing the unexpected woman walk through the game. A similar study was conducted by Simons and Chabris (1999) to determine if the effect could be replicated. In their experiment they used two basketball teams, one was dressed in black and one was dressed in white. Participants were required to count the number of passes that the team in white made. During the task, a gorilla walked into the middle of the court, stopped to thump his chest, and then walked away. In this experiment the gorilla was visible for 5 to 9 seconds before exiting the frame (Simons & Chabris, 1999). Simons and Chabris found that over 73% of people failed to notice the gorilla. Interestingly, both noticers and non-noticers spent the same amount of time fixating on the gorilla, and performed equally well in the primary task. This suggests that people were not ignoring the main task in order to detect the unexpected object. What was even more fascinating was that both noticers and non-noticers looked directly at the object for similar lengths of time which was about 1 second (Mack, 2003; Simons & Chabris, 1999). There was also a significant difference on rates of IB depending on whether or not observers attended to the black or the white team. When participants focused on the team dressed in black, they noticed the gorilla 58% of the time. When participants observed the white team they noticed the gorilla only 27% of the time (Most, Simons, Scholl, Jimenez, Clifford & Chabris, 2011).This suggests that the similarity of the main object in the task to the unexpected stimulus can affect rates of IB across participants. An important finding from these experiments was that fixating on an object does not ensure that the object has been consciously perceived (Memmert, 2006).

Inattentional Amnesia

It has been suggested that an observer's failure to notice a fixated, but unexpected object may be related to a failure of memory instead of attention. Wolfe (1999) first suggested this possibility and referred to the phenomenon as "inattentional amnesia" (Cartwright-Finch & Lavie, 2007; Mack, 2003). This hypothesis suggests that when observers fail to report noticing an unexpected object, they may have actually seen the object but then they simply forgot about it between the time it was viewed and when they were asked to report what they saw (Simons, 2000). This hypothesis has its advantages and disadvantages. Inattentional amnesia supports the theory that encoding into long-term memory is determined by availability of one's working memory. It suggests that lower awareness in a difficult task may be due to reduction in the encoding of critical stimuli into memory. It explains that the mind tries to cope with a difficult task by filtering what should and should not be remembered. Therefore, irrelevant or less important information is forgotten (Cartwright-Finch & Lavie, 2007). However, the reason inattentional amnesia is so heavily criticized, and typically challenged, is because most people find it hard to believe that someone could actually watch a gorilla walk across a basketball court, thump its chest, walk off, and then completely forget that they ever saw that happen (Mack, 2003).

Perceptual Load Theory

Although people tend to disagree about the inattentional amnesia hypothesis, it does support the notion that there is a relationship between task complexity and perception. This is relevant to the perceptual load theory proposed by Lavie (1995). The perceptual load theory of attention posits that processing capacity is finite and that perceptual processing, which is automatic, will continue until capacity for perception is exhausted (Beanland, Allen, & Pammer, 2011). What this means is that in a simple task, when the demands on perception are low, an observer's attentional capacity will have sufficient resources left over to process irrelevant stimuli. This could mean that an observer would be more likely to notice task-irrelevant information in a simple task. It also implies that as a task becomes more difficult, more attention is applied to the primary task, resulting in less perceptual resources being applied to task-irrelevant information (Beanland, Allen, & Pammer, 2011; Belopsky, & Theeuwes, 2010).Therefore, when a task is more difficult, an unexpected object or event would likely go unnoticed. Detection depends largely on whether a primary task exhausts attentional capacity (Cartwright-Finch, & Lavie, 2007). Cartwright-Finch and Lavie (2007) suggested that this strongly supported the notion that attention plays a crucial role in IB.

Cognitive Load Theory

Similar to the perceptual load theory, the cognitive load theory suggests there are finite resources for processing capacity. However, instead of finite resources in perception and attention, cognitive load focuses on finite resources in working memory.

Exhausting working memory can lead to major deficits in performance. For example, when people simulate driving and carry out a verbal task at the same time, performance on both the verbal task and the driving task are impaired (Beanland, Allen, & Pammer, 2011). This explains why engaging in a phone conversation can seriously increase IB in observers. This increase in IB can occur even if the person is not actually talking. The act of simply planning speech can affect cognitive load (Beanland, Allen, & Pammer, 2011). Pizzighello, and Bressan (2008) and Strayer and Johnson (2001) also found that driving performance is not affected by simply paying attention to verbal material. When a person does not engage in conversation or plan speech, they drive perfectly fine. Therefore a person, who is not talking, has less of a cognitive load. In fact, even in the "gorilla" experiment by Simon and Chabris (1999), detection of the unexpected gorilla was observed more in the easy condition than the hard condition (Cartwright-Finch, & Lavie, 2007).

Task Complexity

The relationship between performance on a hard task versus an easy task is not simply a decrease in performance as the task becomes more complex. Typically a search task becomes more difficult when more items, or distractors, are added (Cartwright-Finch & Lavie, 2007). What is interesting about task complexity is that as a task becomes more difficult, observers tend to ignore more distractors and focus only on relevant information in order to efficiently complete the search task (Cartwright-Finch & Lavie, 2007). In a sense, it is applying a filter to a visual search process. This filter can help improve search time until a task becomes too difficult. Another interesting finding is that while attention and working memory can be overwhelmed, it is also possible that it can be underwhelmed which can affect performance.

In controlled settings such as the laboratory, experimenters strive to eliminate any external distractions. However, participants are still susceptible to internal distractions which can be referred to as task-unrelated thoughts (Beanland, Allen, & Pammer, 2011; Giambra, 1995).Task-unrelated thoughts can be considered day-dreaming, or anything that diverts cognitive processing away from the primary task. This diverted cognitive processing can directly result in an increase in IB (Beanland, Allen, & Pammer, 2011). In a study by Beanland (2011), it was observed that during demanding tasks that measured IB, noticers of the unexpected stimulus reported fewer task-unrelated thoughts than non-noticers. It was also observed that during less-demanding tasks, noticers reported more task-unrelated thoughts than non-noticers. This suggests that as a task becomes more demanding, the frequency of task-unrelated thoughts will decrease as well. This is in line with the perceptual load theory. If a task is too easy people have the resources to think about information irrelevant to the task at hand. As the task becomes more difficult people apply more attention to the task, leaving less capacity to facilitate task-unrelated thoughts. It is also important to point out that task-unrelated thoughts point to the possibility that when a task is too easy it can hinder performance.

Item Similarity and Detection

Research suggests that similarity of objects to target stimuli could play a role in detection of unexpected objects. Neisser (1979) examined this relationship but found that observers were no more likely to see an unexpected object when it was similar to the attended item than when it was similar to the ignored items. This suggests that detection is based upon observer's expectations and how much an object stands out in a scene (Most et al., 2001).They came to the conclusion that similarity did not play a role in detection of unexpected objects. However, Simon and Chabris (1999) ran an experiment where observers attended to a primary visual task, and on one of the trials an unexpected cross would appear. They found that observers were more likely to notice the unexpected cross when it was similar in luminance to the attended items. They also found that when the luminance of the cross was similar to ignored items, the cross typically remained undetected (Most et al., 2001).The likelihood of detection relates to the visual similarity between the expected and the unexpected stimuli (Most et al., 2001). Duncan and Humphrey (1989) suggested that this may be due to selectively ignoring items in the visual field that are similar to unattended items. Findings from research by Duncan and Humphrey (1989) acknowledge that search performance largely depends on how similar distractors are to each other and how dissimilar they are from the target. A finding by Proulx and Egeth (2006) confirmed that the distraction caused by irrelevant features of objects, such as luminance, was based on the similarity between the attended and unattended items in the visual field. Research also suggests that as target items and non-target items become more similar, search tasks become more difficult. With increasing difficulty in the visual task, the detection of the presence of an irrelevant, but bright object is decreased (Belopolsky & Theeuwes, 2010). Overall, it appears that similarity of an unexpected object to attended items in the visual field can decrease rates of IB. However, if the unexpected objected significantly contrasted the attended would it be noticeable enough to reduce rates of IB.

Salience

Salience can be defined as how much an object stands out in relation to other objects in the visual field. In IB paradigms, a common stimulus used is the feature singleton. A feature singleton is a stimulus that is highly salient and stands out in a display. For example, there could be a single red item in a display where all of the other items are grey. When searching for this item it usually requires minimal effort because its features stand out relative to other items in the visual field (Theeuwes, 2004). In an experiment by Theeuwes, salience of a color singleton was examined in relation to search tasks. In a search task for a single green diamond, the presence of a single red circle caused interference in the search task. When the salience of the items was reduced, by making the color of both the circle and the diamond similar to non-target items, there was less interference by the irrelevant red circle (Theeuwes, 2004). Theeuwes came to the conclusion that attention can be captured automatically by the object that stands out most in the visual display regardless of whatever the observer is looking for. How much a color singleton stood out was directly related to how salient it was, and as it became less salient it became harder to detect (Theeuwes, 1992). An object can also be salient due to its association with biologically significant stimuli. For example, body silhouettes, happy faces, or someone's name can automatically capture attention (Cartwright-Finch, & Lavie, 2007). While one would think that salience would be enough to detect an unexpected object, Most et al., (2001) found that salience is not enough to guarantee detection of an unexpected object. Observers may still fail to detect the only red object in a display with all white letters (Beanland, Allen, & Pammer, 2011). It has been suggested that the phenomenon of failing to notice such an obvious item may be due to one's attentional set, and the relation between bottom-up versus top-down processing. Both can help explain why objects similar to attended items can be noticed more easily, and why objects that significantly contrast attended items can be easily detected as well

Bottom Up Versus Top Down Processing

Bottom-up versus top-down processing is a point of interest in a lot of research on attention. Bottom-up processing, or stimulus-driven processing, refers to the attributes of certain stimuli that capture our attention, regardless of our expectations (Belopolsky & Theeuwes, 2010). Essentially, bottom-up processing occurs when something captures your attention when you were not necessarily looking for it. Top-down processing is the ability to select certain attributes that are relevant for the task at hand (Belopolsky & Theeuwes, 2010). This implies that when someone is searching for the only red diamond in a group of green circles they may look for the shape of a diamond or the color red to find the object. Top-down processing emphasizes that the search is a conscious effort, while bottom-up processing implies that processing occurs naturally and without expectations. There is debate over which type of processing is used in attentional capture and which occurs first. When looking at salient objects, bottom-up processing would seem to occur first. Stimuli that are extremely salient and stand out in a display can catch attention without any expectation of the stimuli being there. In these paradigms a salient object can catch attention regardless of how much time is given for the task, which suggests that bottom-up processing can occur before one can consciously search for objects in the display (Theeuwes, 2004). In Theeuwes' experiment, even though she had participants using top-down processing of information, an irrelevant, salient object still managed to distract the observers. This led Theeuwes to conclude that attention could be captured automatically by the most salient object in the display (Theeuwes, 2004). Most et al. (2001) suggested that top-down processes may cause one to pay attention only to critical features of the object in the search task while preventing attention from being distracted by other features or items in the visual display. Bacon and Egeth (1994) explained that the absence of attentional capture can be explained by the type of search that observers perform. They explained that top-down control functions under feature and singleton search mode. When observers use singleton detection mode, they direct attention to locations where there are most salient objects. When they use a feature search mode they direct attention to only observe particular features (Belopolsky & Theeuwes, 2010). Bacon and Egeth explained that when participants use singleton detection, all irrelevant singletons capture attention because they are observing an area with a high contrast, and when observers are using feature search mode, irrelevant stimuli fail to capture attention (Belopolsky & Theeuwes, 2010). The debate continues over whether or not attention is required for detecting simple features that stand out in the visual field.

While there is no conclusive evidence in the discussion versus bottom-up and top-down processing, both help to explain why some items can be detected and others fail to be noticed.

What Counts as Attentional Capture?

Since IB occurs when an object that is in plain sight goes undetected, it would be logical to assume that attentional capture is the absence of IB. However, there are discrepancies with what counts as attentional capture. Consider that simply fixating on an object does not imply that the object has captured attention. Among the various types of attentional capture there is explicit and implicit attentional capture. Explicit attentional capture happens when an unattended, salient item is focused on, leading to awareness of its existence (Simons, 2000). In implicit attentional capture, an irrelevant stimulus influences performance on a different task, irrespective of whether or not its presence was known (Simons, 2000). In both explicit and implicit attentional capture the items distract the observer and alter performance. However, the difference is that in explicit attentional capture observers are aware of the item, and in implicit attentional capture they might not realize that the object was present (Simons, 2000). What is interesting about attentional capture is that reporting that one saw an unexpected object may not necessarily be considered attentional capture, but failure to notice the critical stimulus would suggest that the critical stimulus failed to capture attention explicitly (Simons, 2000). In some studies on IB and attentional capture, the critical stimulus is irrelevant to the task observers perform, and awareness of the objects presence is based on response times or eye movements (Simons, 2000).

There are multiple classifications of attentional capture that can be used in a study. In the Additional Singleton task, participants participate in a search task where an additional item appears in the visual display. In this paradigm evidence for capture can be attributed to slower search times when the unexpected object appears in the display (Simons, 2000). In Oculomotor Capture paradigms, participants are required to perform a search task and eye movements are observed via an eye-tracker. When the unexpected item appears in the display, evidence for capture is a result of eye movement towards the unexpected item (Simons, 2000). In the Irrelevant Feature search task, an irrelevant and unexpected item appears either as either a target or a distractor, and evidence for capture is through faster performance when the object was the target (Simons, 2000). In most attentional capture paradigms, the use of awareness is considered more conservative. This is because attention has been considered the gate to awareness. Therefore if a person is consciously aware of an objects presence then it has captured attention (Dehaene & Naccache, 2001; Lo, & Yeh, 2008). In IB paradigms, a common way to find if an object failed to capture attention consciously is through a post-visual search task called the forced choice response.

After an experiment is completed, observers can perform a forced choice response task which involves selecting what they thought the unexpected object was in visual search task. Observers typically say what the unexpected item was by selecting an item from a list of possible critical stimuli. Moore, Grosjean and Lleras (2003) used the forced choice task to offer an operational definition for IB. When participants claimed they did not see the critical stimulus, and when their forced responses were still incorrect, IB had occurred. In IB paradigms, inattention is an assumption but unawareness can be confirmed through the forced choice response (Lo, & Yeh, 2008).

Eye Movements and Inattentional Blindness

Eye movements may also have an effect on IB. The eye moves in saccades, which are quick jumps from one area to another in the visual display. When the eye performs this movement, vision is hindered (Pieters, & Warlop, 1999). When the eye pauses between saccades, fixation occurs. This is when the eye has, for the most part, ceased movement and when the visual system can gather information (Pieters, & Warlop, 1999). When a visual task becomes more difficult, observers speed up information collection and processing, which can be done by increasing the speed of acquiring visual information, and reducing how long one fixates on any one particular object (Pieters, & Warlop, 1999). Because there is a blur on the retina when the eye moves from fixation point to fixation point, an object might appear less visible in a complex task (Cartwright-Finch, & Lavie, 2007). Another reason an observer may fail to notice a particular stimuli in the visual display is due to the attentional blink.

Attentional Blink

The phenomenon of IB involves spatial attention, while attentional blink involves temporal attention (Beanland, Allen, & Pammer, 2011). The attentional blink can occur when a critical stimulus is rapidly followed by another stimulus (usually within 100 ms), causing processing of the first stimulus to be disrupted (Lo, & Yeh, 2008). The fact that two objects cannot be perceived at the same time would help to explain why when one object is presented very quickly after another, the first one is difficult to perceive. This phenomenon can also be observed in bistable figures such as the vase-face pattern (Rubin, 1921). In this pattern, one can see either two faces or a vase in between the two faces, but only one can be perceived at any given time (Lo, & Yeh, 2008). While this may not be a definitive reason for IB, it is important to consider how rapidly stimuli are presented may alter results in IB paradigms. There is one concept involving attention that must be discussed, which is referred to as the attentional window.

Attentional Window

Visual attention can be thought of as a "window or spotlight" that can affect speed and threshold for noticing events in the visual display. It exists as movements of the eyes, which act as "spotlights of attention" that focus on the designated area (Pieters, & Warlop, 1999). This window of attention can be either widened or narrowed depending on what is most efficient for the task at hand. Typically when the attentional window is wider, observers focus on a broader area, but sacrifice attention to finer detail in order to process more events in the visual field. When the attentional window is narrowed, there is a finer attention to detail and processing of information can be more effective. The sacrifice a person makes by narrowing the attentional window is failure to detect details outside of the area where attention is focused. The narrowing of the attentional window could result in failure detect items such as a color singleton, or an otherwise noticeable salient object (Theeuwes, 2004). The advantage of narrowing the attentional window is that distractors outside the attentional window remain undetected and fail to distract the observer. The attentional window is typically larger when a task is relatively simple, but narrows as a task increases in complexity. This is because a greater attention to detail may be required to effectively complete a task. Attention can be captured outside of the attentional window only through bottom-up processing, but it becomes more difficult for this to occur as the attentional window narrows (Theeuwes, 2004). Overall, the attentional window plays a critical role in determining what items will capture attention. As the window widens, salient objects will be likely to capture attention, but when it is smaller salient items outside of the attentional window could be ignored (Belopolsky, & Theeuwes, 2010). This means that when attention is focused at a certain location before the search task begins, the search would be less efficient because the window has already been narrowed (Belopolsky, Theeuwes, 2010). In the debate over whether or not the window is under top-down or bottom-up control, Belopolsky and Theeuwes (2010) explained that the size of the window is under top-down control. Within the window bottom-up processing can override top-down processing when a salient feature is detected. This further explains why a salient object can go undetected, and possibly another reason why IB could occur. Overall, there is an abundance of literature focusing on manipulating the visual field and how it pertains to rates of inattentional blindness. Is it possible then that auditory stimuli could have similar effects?

Auditory Stimuli and Inattentional Blindness

Research from Olivers and Nieuwenhuis (2005) found that when using the attentional blink paradigm, audio stimuli can improve visual awareness. They concluded that an explanation for this effect was that people invest too much effort into the primary task, so auditory stimuli served to disperse attention more broadly. This broader focus actually reduced the attentional blink in observers, which improved stimulus awareness (Beanland, Allen,& Pammer,2011; Olivers & Nieuwenhuis, 2006). It has also been proposed that listening to music increases task performance simply because it puts participants in a better mood (Olivers & Nieuwenhuis 2006). An experiment was conducted by Olivers and Nieuwenhuis (2006) to assess if this would affect rates of IB. They found that mood did increase significantly, but found that changes in mood did not affect rates of IB (Beanland, Allen, & Pammer, 2011). Beanland et al. (2011) found that within IB paradigms, listening to auditory stimuli that involved language such as music with lyrics or stories actually reduced rates of IB, but that instrumental music did not show a significant decrease in IB (Beanland, Allen, & Pammer, 2011). Peretz and Coltheart (2003) explain that both music and lyrics are processed in different areas of the brain which could help explain why instrumental music did not affect rates of IB while music with lyrics reduced rates of IB. Beanland (2011), Forster and Lavie, (2007, 2008) examined how task complexity and auditory stimuli affected rates of IB, and found that even though observers were attending to an auditory task while completing a visual search task, rates of IB decreased. This is counterintuitive to the cognitive load theory which suggests that as a person has more tasks to attend to, efficiency in the visual search task should decrease. In Beanland's experiment, he explains that this could be due to how simple their primary task was.

Beanland also proposes that perhaps the relationship between cognitive load and IB is U-shaped, where a moderate cognitive load results in the lowest rates of IB. If the task is too easy, observers could become easily distracted by task-unrelated thoughts or become bored and distracted causing performance in the primary search task to suffer. If the primary task is too difficult, IB would occur because the observer lacks the attentional capacity to process the unexpected stimulus (Beanland, Allen, & Pammer, 2011). Beanland (2011) manipulated his auditory tasks into an easy task (simply listening to a familiar song) and a difficult auditory task (listening to a familiar song with distracting beeps inserted at random points). He also manipulated the visual search task by making an easy task and a difficult task. In the control group with no audio stimuli, observers became uninterested in the task and task unrelated thoughts occurred, resulting in IB. With a simple listening task, there was a slight increase in cognitive load which eliminated task-unrelated thoughts but left sufficient attentional resources to process the unexpected object the appeared in the visual display (Beanland, Allen, & Pammer, 2011). Beanland also found that when visual load was low, IB rates were higher than under high visual load. When participants were under high auditory load, their rates of IB were lower than low visual load conditions. He also found that there was no difference between the low visual load, and low auditory load groups (Beanland, Allen, & Pammer, 2011). What this means is that when the difficulty of the visual or audio task was low, rates of IB were high. As either the visual or auditory task became more difficult, observers became more engaged in the task causing IB rates to decrease. There was a threshold to this effect, and when the visual task became too demanding, rates of IB increased and performance in the primary task decreased. Beanland also found that when observers actively paid attention to the music to detect embedded tones, participants did better in the primary task and rates of IB were reduced. This means that increasing the difficulty of audio and visual tasks did not produce equivalent results. Overall the trend appears to be that increases in visual demands can increase IB, while increasing audio demands will result overall in a decrease in IB (Beanland, Allen, & Pammer, 2011).

Beanland's experiment also explains that level of engagement with the audio stimuli can affect the likelihood of IB. When given no instruction with the audio stimuli (which was the low audio condition in Beanland's experiment) visual performance was unaffected. However, when participants were told to focus on the auditory stimuli IB was reduced. Beanland explains that this is because additional task demands by attending to auditory stimuli are not too demanding when participants do not have to remember any details of the stimuli (Beanland, Allen, & Pammer, 2011). It is possible that familiarity with the audio stimuli could also play an effect on whether an unexpected object will be detected. When encoding of unfamiliar auditory information is required in a task, the demands of the task significantly increase which causes IB to become more likely to occur (Pizzighello & Bressan 2008). Overall Beanland explains that in order for an audio task to facilitate the detection of an unexpected object or event, it must be distracting but not demanding (Beanland, Allen, & Pammer, 2011). One reason this could be possible is because auditory stimuli distract observers to the extent that their attentional set is not as strong, which would allow objects that would normally be ignored and deemed irrelevant to be processed (Beanland, Allen, & Pammer, 2011). Boot, Brockmole and Simons (2005) also explain that IB paradigms with abrupt onsets are less likely to capture attention with an auditory task than a search task for an irrelevant color singleton (Beanland, Allen, & Pammer, 2011). Contradictory to the finding that music can decrease IB, is research by Pizzighello and Bressan (2008) who suggested that music can actually worsen the effect.

Pizzighello and Bressan (2008) created a visual task that required participants to count the number of bounces of moving items, and an audio task that required observers to attend to verbal material that they were required to remember. In the first experiment, participants were told to listen to the auditory stimulus because they would be tested on their comprehension of the material played to them. When this task was combined with the visual task, performance in both the auditory and visual task suffered. They also reported that there was no significant difference between rates of IB for people in the dual task and people in the auditory task by itself (Pizzighello, & Bressan, 2008). Based on their findings the researchers concluded that adding an auditory task to visual task actually worsens IB. An explanation for why this happens could be that, in order to focus on the auditory information, observers must stop focusing on the visual stream and only pay attention the auditory stream (Pizzighello, & Bressan, 2008). Pizzighello and Bressan (2008) explain that observers switch between auditory and visual information processing so well that they are unaware that they are ignoring one of the stimuli at all times. This finding, if true, could have serious implications for people who drive. This research implies that listening to the radio or music while driving would actually impair one's ability to detect unexpected objects on the road. There is research that points to auditory information decreasing and increasing rates of IB, posing a blatant contradiction.

Unfortunately, due to the limited amount of time allotted to completing this research, focusing on inattentional blindness to understand its effects is not possible for several reasons. Inattentional blindness is difficult to test on a large number of people because participants can only run through the experiment once. Confirming that participants saw the unexpected object could also prove to be difficult across participants without the use of an eye tracker. Furthermore, there are different interpretations as to the operational definition of detection. IB is an implied status because the observer must deny seeing an unexpected object in order for it to be classified as IB, but that pulls in debate whether or not it was detected subconsciously. Instead this research has turned to focus on a similar phenomenon that focuses on failure to detect changes in the visual scene.

Change Blindness

Related to inattentional blindness is change blindness. Dan Simons (1997) defined change blindness as the failure to detect changes to an object or scene. Like inattentional blindness, change blindness suggests that people are insensitive to changes between two similar photos, videos and real world scenarios. A popular paradigm used in experiments analyzing change blindness is the flicker paradigm. The flicker paradigm involves using two similar images with a subtle change between the images. The two pictures are flashed back and forth repeatedly with a neutral, gray screen shown briefly in between the two similar images. Although people would intuitively believe they could detect a change, it could go unnoticed or take an extended amount of time to detect. In an experiment by Dan Simons (1997), participants engaged in a conversation with an experimenter and at some point the experimenter switched places with a different person. Interestingly, the change went unnoticed by participants the majority of the time. Since change blindness shares so many similarities with inattentional blindness is it possible that it could also be affected positively or negatively by an auditory stimulus?

In the current study, I examined whether concurrent auditory stimulation affects rates of change blindness. If auditory stimulation can distract people without overloading their attentional capacity, as suggested by Beanland (2010), then I would expect participants in an auditory condition to perform better than a control group in a change detection paradigm. In an audio condition, participants should be more accurate and faster in detecting changes than their counterparts in a control group. This would be a contradiction to Pizzighello and Bressan's (2008) research that suggests an auditory stimulus would impair rates of detection in the visual field.

METHODS

Participants

To answer this question, 40 students from the University of Central Florida were recruited from the psychology department participant pool and randomly assigned to 1 of 2 conditions. Participants' ages ranged from 18 to 22 with the average age being 20. Concerning gender, 31 of the participants were female, and 9 of the participants were males. Manipulations of auditory stimuli consisted of a control group that listened to no auditory information, and a music condition that attended to a familiar song. The familiar song in this experiment was "Y.M.C.A." by The Village People. Both conditions were asked to wear noise-cancelling headphones for the experiment. 19 participants were in the control condition, and 21 participants were in the music condition.

Design and Procedure

The task consisted of a practice trial and the actual experiment. Both the practice trial and the actual experiment used the flicker paradigm via the program E-Prime. The flicker paradigm in the practice experiment consisted of 1 pair of images that had a change. Participants were asked to press 1 if they detected a change between the images, or 0 if they believed there was no change between the two images. Images were shown for 1 second and had a neutral gray screen that was flashed in between the images for 50 milliseconds. Once participants answered a screen telling their time of completion was displayed. After participants completed the practice trial, they participated in the actual experiment. The real experiment used 34 pairs of pictures, with 17 that had changes and

17 that were identical. The pictures typically involved scenery and changes were as simple as a window disappearing from a building and reappearing. An example of an image set with a change can be seen in Figure 1. The pairs of pictures were randomly shown, and the participants' responses were both timed and recorded for accuracy. The response times were recorded and the time that the first frame and the neutral screen were first shown was subtracted to eliminate responses from participants who had not seen both images before responding.

RESULTS

Accuracy

Accuracy data are shown in Figure 2. Accuracy in the music condition for images with changes (*M*=0.39, *SD*=0.15) was similar to the control group for images with changes (*M*=0.48, *SD*=0.11). Similarly, when looking at accuracy for images with no change across conditions, the participants in the music condition (*M*=0.88, *SD*=0.21) performed as well as those in the control condition (*M*=0.90, *SD*=0.20). This pattern reflects an insignificant change x group interaction, ($F(1, 38) = 0.96$, $p = .34$). When there was no change participants were more accurate than when there was one ($F(1,38) = 110.06$, $p < .005$). There was no main effect for group ($F(1,38)= 2.87$, $p > 05$); the presence of music did not affect accuracy.

Reaction Times

Reaction times for trials in which there was a correct response were analyzed and are displayed in Figure 3. There was a significant main effect of change presence, reflecting the fact that participants took longer to respond when there was a change ($F(1, 38) = 11.07$, $p < .005$). The main effect of group did not reach significant ($F(1, 38) = 2.46$, $p = .125$). Interestingly, the control group (*M*=471 ms, *SD*=101 ms) took less time to detect a change than the music group (*M*=577 ms, *SD*=144 ms) when there was a change between images. When there was no change between images, the control groups' reaction times (*M*=464 ms, *SD*=72 ms) did not differ from the music conditions reaction times (*M*=442 ms, *SD*=98 ms). A significant interaction supports this interpretation

($F(1,38) = 9.11$, $p < .005$). This implies that the effect of music on reaction time was dependent upon whether or not a change occurred on a given trial.

DISCUSSION

Overall, I found that music slowed reaction times among participants when a change was present in the pictures, but not when there was no change. This finding contradicted my prediction that music would help performance in both reaction times and accuracy in the presence of images with changes. In terms of accuracy, both groups were similarly accurate in the presence of both images with changes and images with no changes, and music did not have a significant effect on participants' response accuracy. It is important to consider that participants in both conditions were much more accurate in detecting pictures with no changes as opposed to pictures with changes. While it is possible that this could be a result of participants not taking the experiment seriously, it seems more likely that this pattern reflects the fact that changes were rather difficult to detect in the current task. If participants were simply not engaging in the task then I would have expected to find similarly low accuracy rates in no change trials as well. Therefore, future studies should use images with more obvious changes between the two images to assess whether my observed pattern of data is preserved in easier change detection tasks with higher accuracy.

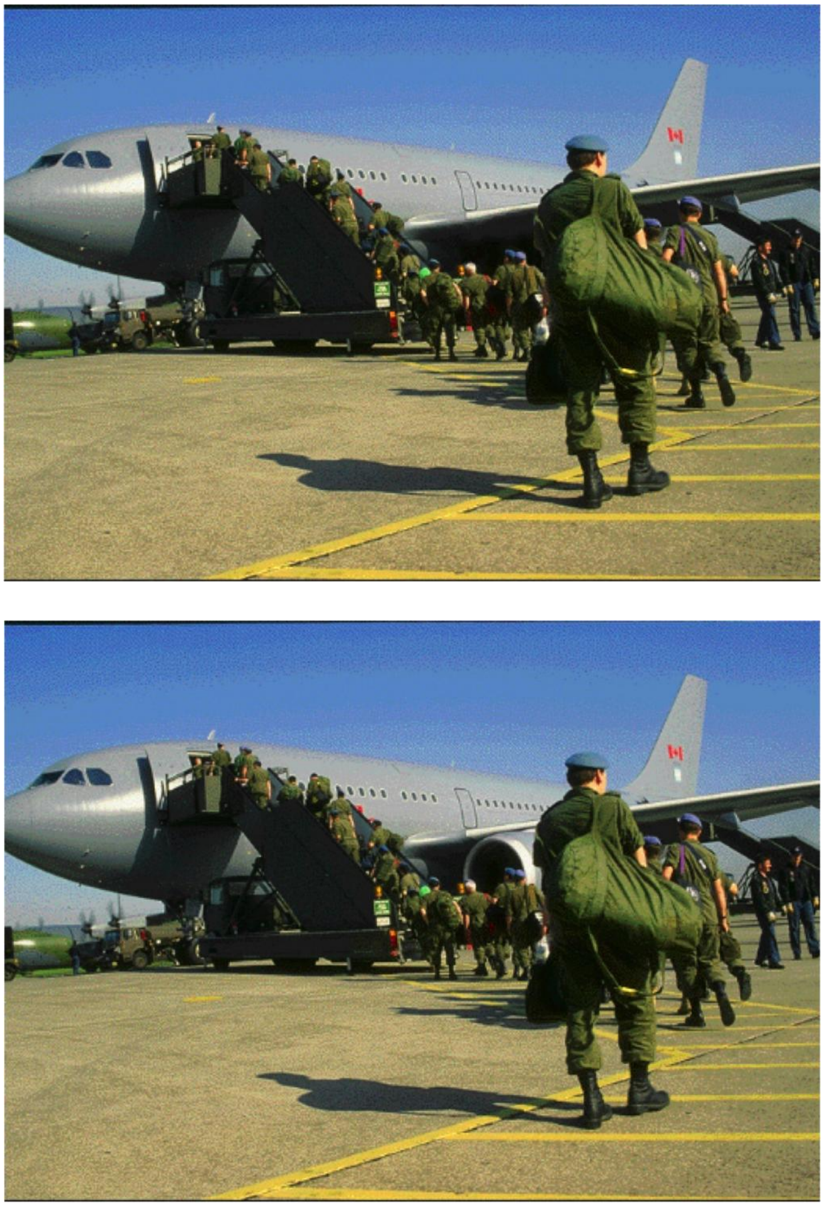
When looking at the effects of an auditory stimulus on change blindness it is important to consider that most of the research reported in this literature was mainly based off of studies involving inattentional blindness. The intention of this paper was to extend Beanland and Pammer's (2011) finding, that music decreased rates of blindness in an experiment involving detection. Beanland and Pammer's (2011) research contradicted Pizzighello and Bressan's (2008) claim that music increased rates of inattentional blindness. Beanland and Pammer (2011) argued that previous research was using too difficult of a task, and with an adequate level of complexity music would affect detection rates. My findings were more in line with Pizzighello and Bressan's (2008) finding that participants listening to music took significantly longer to respond to images with changes than participants without music. When looking at accurate responses only, response times were actually faster in the music condition when there was no change in the image.

As previously mentioned, a limitation of the current study was the observation of generally low accuracy in change trials. Because accuracy in change trials was low, conclusions drawn from the data must be made with some degree of caution (though I did find significant differences despite the high error rates). As noted, future studies should attempt to replicate the current findings using a change detection task in which changes are correctly detected with higher accuracy.

It could also be useful to examine varying types of auditory stimuli to determine if they would yield different results. More trials could also prove useful since this research only involved 34 sets of images with 17 images with changes and 17 images with no changes. Hopefully, this research can contribute to the limited literature analyzing the effects of auditory stimuli on change detection, and assist researchers in finding ways to improve rates of detection.

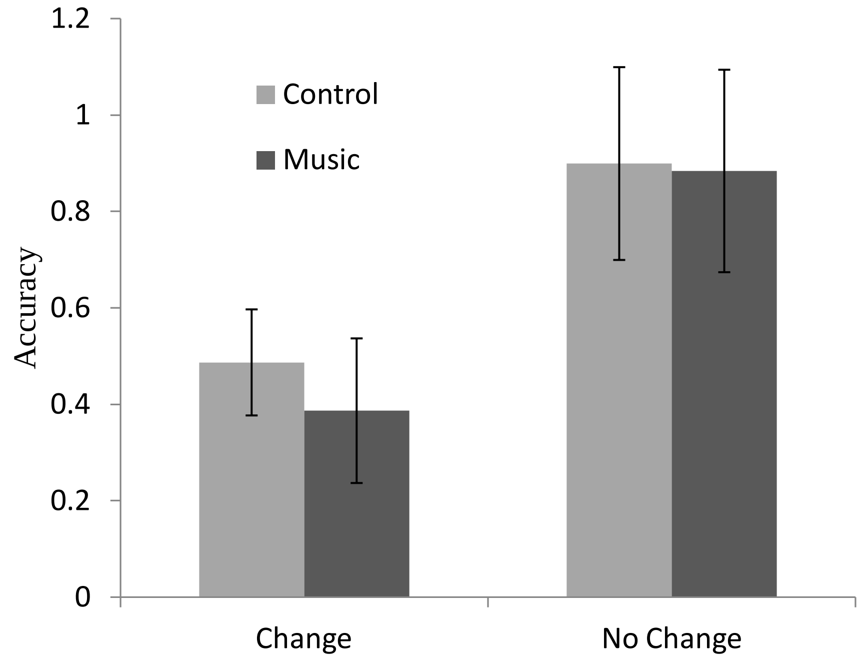
APPENDIX: LIST OF FIGURES

Figure 1



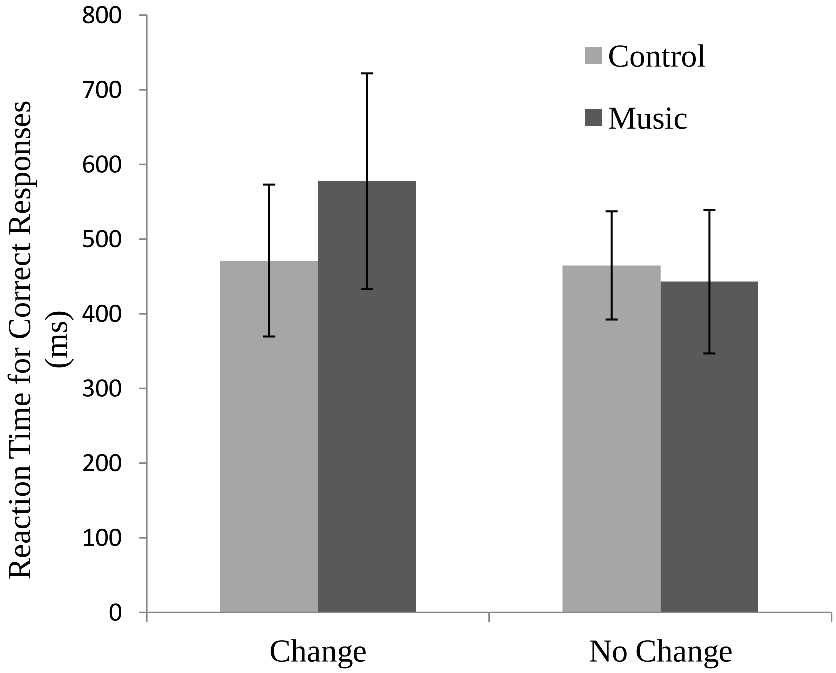
An example of a change between pictures can be seen here. Notice how the turbine engine behind the soldiers disappears and reappears.

Figure 2



This figure focuses on Accuracy in both the control and music conditions. In both conditions accuracy was much higher in the pictures with no changes. Both conditions performed with similar accuracy in both the change and no change conditions.

Figure 3



This figure shows the reaction times of only the correct responses. For both the change and no change conditions, the control group's reaction times remained fairly constant. In the music condition participants took longer to respond to images with changes. In images with no changes the music condition took slightly less time to respond versus the control condition.

REFERENCES

Bacon, W. F., & Egeth, H. E. (1994). Overriding stimulus-driven attentional capture. *Attention, Perception, & Psychophysics*, *55*(5), 485-496.

Beanland, V., & Pammer, K. (2010). Looking without seeing or seeing without looking? Eye movements in sustained inattentional blindness. *Vision research*, *50*(10), 977-988.

Beanland, V., Allen, R. A., & Pammer, K. (2011). Attending to music decreases inattentional blindness. *Consciousness and cognition*, *20*(4), 1282-1292.

Belopolsky, A. V., & Theeuwes, J. (2010). No capture outside the attentional window. *Vision research*, *50*(23), 2543-2550.

Boot, W. R., Brockmole, J. R., & Simons, D. J. (2005). Attention capture is modulated in dual-task situations. Psychonomic Bulletin & Review, 12(4), 662-668.

Cartwright-Finch, U., & Lavie, N. (2007). The role of perceptual load in inattentional blindness. *Cognition*, *102*(3), 321-340.

Duncan, J., & Humphreys, G. W. (1989). Visual search and stimulus similarity. *Psychological Review; Psychological Review*, *96*(3), 433. (Proulx & Egeth 2006)

Folk, C. L., Remington, R. W., & Johnston, J. C. (1992). Involuntary covert orienting is contingent on attentional control settings. *Journal of experimental psychology: Human perception and performance*, *18*(4), 1030.

Forster, S., & Lavie, N. (2007). High Perceptual Load Makes Everybody Equal Eliminating Individual Differences in Distractibility With Load. *Psychological science*, *18*(5), 377-381.

Forster, S., & Lavie, N. (2008). Attentional capture by entirely irrelevant distractors. *Visual Cognition*, *16*(2-3), 200-214.

Giambra, L. M. (1995). A laboratory method for investigating influences on switching attention to task-unrelated imagery and thought. *Consciousness and cognition*, *4*(1), 1-21.

Haines, R. F. (1991). A breakdown in simultaneous information processing. *Presbyopia research. From molecular biology to visual adaptation*, 171-175.

Koivisto, M., Hyönä, J., & Revonsuo, A. (2004). The effects of eye movements, spatial attention, and stimulus features on inattentional blindness. *Vision Research*, *44*(27), 3211-3221.

Lavie, N. (1995). Perceptual load as a necessary condition for selective attention. *Journal of Experimental Psychology: Human Perception and Performance*, *21*(3), 451.

Lo, S. Y., & Yeh, S. L. (2008). Dissociation of processing time and awareness by the inattentional blindness paradigm. *Consciousness and Cognition*, *17*(4), 1169-1180.

Mack, A. (2003). Inattentional Blindness Looking Without Seeing. *Current Directions in Psychological Science*, *12*(5), 180-184.

Memmert, D. (2006). The effects of eye movements, age, and expertise on inattentional blindness. *Consciousness and cognition*, *15*(3), 620-627.

Moore, C., Grosjean, M., & Lleras, A. (2003). Using inattentional blindness as an operational definition of unattended: The case of surface completion. *Visual Cognition*, *10*(3), 299-318.

Most, S. B., Simons, D. J., Scholl, B. J., Jimenez, R., Clifford, E., & Chabris, C. F. (2001). How not to be seen: The contribution of similarity and selective ignoring to sustained inattentional blindness. *Psychological Science*, *12*(1), 9-17.

Naccache, L., & Dehaene, S. (2001). Unconscious semantic priming extends to novel unseen stimuli. *Cognition*, *80*(3), 223-237.

Neisser, U. (1979). The control of information pickup in selective looking. *Perception and its development: A tribute to Eleanor J. Gibson*, 201-219.

Olivers, C. N., & Nieuwenhuis, S. (2005). The beneficial effect of concurrent task-irrelevant mental activity on temporal attention. *Psychological Science*, *16*(4), 265-269.

Peretz, I., & Coltheart, M. (2003). Modularity of music processing. Nature neuroscience, 6(7), 688-691.

Pieters, R., & Warlop, L. (1999). Visual attention during brand choice: The impact of time pressure and task motivation. *International Journal of Research in Marketing*, *16*(1), 1-16.

Pizzighello, S., & Bressan, P. (2008). Auditory attention causes visual inattentional blindness. *Perception*, *37*(6), 859.

Simons, D. J. (2000). Attentional capture and inattentional blindness. *Trends in cognitive sciences, 4*(4), 147-155.

Simons, D. J., & Chabris, C. F. (1999). Gorillas in our midst: Sustained inattentional blindness for dynamic events. *Perception-London*, *28*(9), 1059-1074.

Simons, D. J. & Levin D. T. (1997). Change Blindness. *Trends in Cognitive Science, 1*(7), 261-267

Strayer, D. L., & Johnston, W. A. (2001). Driven to distraction: Dual-task studies of simulated driving and conversing on a cellular telephone. *Psychological science*, *12*(6), 462-466.

Theeuwes, J. (1991). Cross-dimensional perceptual selectivity. *Attention, Perception, & Psychophysics*, *50*(2), 184-193.

Theeuwes, J. (1992). Perceptual selectivity for color and form. *Attention, Perception, & Psychophysics*, *51*(6), 599-606.

Theeuwes, J. (1994). Stimulus-driven capture and attentional set: selective search for color and visual abrupt onsets. *Journal of Experimental Psychology: Human perception and performance*, *20*(4), 799.

Theeuwes, J. (2004). Top-down search strategies cannot override attentional capture. *Psychonomic Bulletin & Review*, *11*(1), 65-70.

White, R. C., & Davies, A. A. (2008). Attention set for number: Expectation and perceptual load in inattentional blindness. *Journal of Experimental Psychology: Human Perception and Performance; Journal of Experimental Psychology: Human Perception and Performance*, *34*(5), 1092

Wolfe, J. M. (1999). Inattentional Amnesia Jeremy M. Wolfe. *Fleeting memories: Cognition of brief visual stimuli*, 71.